WHAT IS CLAIMED IS:

1. A brake pressure estimating apparatus for an automotive vehicle, comprising:

a brake system including a master cylinder which develops a hydraulic in response to at least a brake manipulation as a hydraulic source and a brake pressure controlling section that is enabled to arbitrarily control a brake pressure of each wheel cylinder;

a first wheel cylinder brake liquid pressure estimating section that estimates a first brake liquid pressure of the wheel cylinder of each road wheel on the basis of a model of the brake pressure controlling section for each control period;

a second wheel cylinder brake liquid pressure estimating section that estimates a second brake liquid pressure of the wheel cylinder for each road wheel on the basis of a vehicular model with a vehicular state as an element of the model for each control period; and

a master cylinder liquid pressure estimating section that estimates a liquid pressure of the master cylinder for each control period on the basis of the first and second brake liquid pressure estimated values of the wheel cylinder of each road wheel estimated by the first wheel cylinder liquid pressure estimating section and the second wheel cylinder brake liquid pressure estimating section, the first wheel cylinder liquid pressure estimating section calculating section that calculates the first brake liquid pressure of the wheel cylinder of each road wheel on the basis of the master cylinder liquid

pressure estimated value estimated at a previous control period and the first liquid pressure estimated value estimated at the previous control period, the second wheel cylinder brake liquid pressure estimating section including a vehicular motion state detecting section that detects a vehicular state and calculating the second wheel cylinder brake liquid pressure for each road wheel from the detected vehicular motion state, and the master cylinder liquid pressure estimating section outputting the master cylinder liquid pressure estimated value to make a difference between the first wheel cylinder brake liquid pressure estimated value and the second wheel cylinder brake liquid pressure estimated value small to the first wheel cylinder brake liquid pressure estimating section to cause the master cylinder liquid pressure estimated value to be converged into a true value thereof.

2. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 1, wherein the vehicular motion state detecting section equipped in the second wheel cylinder brake liquid pressure estimating section includes a detecting section to detect a wheel velocity variation rate of one of the wheels which is a controlled object and the master cylinder liquid pressure estimating section makes the first brake liquid pressure estimated value approach to the second brake liquid pressure to make the difference between the first brake liquid pressure estimated value and the second brake liquid pressure estimated value small to converge the master cylinder estimated liquid pressure into the true value thereof.

3. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 1, wherein the second liquid pressure estimating section comprises: a maximum brake liquid pressure calculating section that calculates a maximum brake liquid pressure P_{B_MAX} by which each road wheel is enabled to be braked at maximum on the basis of a braking liquid pressure P_{STAT} under a static wheel load and a wheel load movement due to a vehicular braking or vehicular turning; a braking liquid pressure variation rate calculating section that calculates a braking liquid pressure variation rate P_{BDEF} caused by a road wheel moment by multiplying a variation rate of a corresponding vehicular road wheel velocity per unit time $\dot{V}w$ detected by a wheel velocity detecting section with a predetermined coefficient K_{VW} related to a vehicular inertia moment; a determination coefficient calculating section that calculates a determination coefficient $P_{B\_ROAD\_RETIO}$ to determine whether a driven wheel is under a pressure increase state or under a pressure decrease state as follows: $P_{B\_ROAD\_RETIO} = P_{B\_ROAD\_RETIO} + INCN(w/c) \bullet K_{INC} - DECN(w/c) \bullet K_{DEC}$, wherein $P_{B\_ROAD\_RETIO}$ at a right side term of the above equation denotes $P_{B\_ROAD\_RETIO}$ at the previous control period, INCN (w/c) denotes a pressure increase pulse duration, DECN(w/c) denotes a pressure decrease pulse duration, K_{INC} denotes a coefficient to convert the pressure increase pulse duration INCN to a hydraulic pressure, and K_{DEC} denotes a coefficient to convert the pressure decrease pulse duration DECN to the hydraulic pressure; an each road wheel cylinder brake liquid

pressure calculating section that calculates each road wheel braking liquid pressure P_{B_ROAD} as follows: $P_{B\_ROAD} = (P_{B\_ROAD\_RETIO}/\sum(P_{B\_ROAD\_RETIO})) \bullet X_G \bullet K_{PB}$, wherein X_G denotes a longitudinal acceleration of the vehicle and K_{PB} denotes a coefficient determined as a vehicular weight and vehicular road wheel brake pad frictional coefficient μ; and a second brake liquid pressure estimated value outputting section that calculates and outputs the wheel cylinder liquid pressure estimated value for each road wheel $P\hat{\ }_{WC}$ as follows: $P\hat{\ }_{WC} = \min(P_{B\_ROAD}, P_{B\_MAX}) + P_{BDF}$.

4. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 3, wherein the first wheel cylinder brake liquid pressure estimating section comprises: a pump increase determining section that determines whether a hydraulic pump pressure increase occurs in the model of the pressure controlling section; a wheel cylinder inflow quantity calculating section that calculates a wheel cylinder inflow quantity Q_{IN}, when the hydraulic pump pressure increase occurs, as follows: $Q_{IN} = K_{PUMP} \bullet INCN(G/V)$, wherein INCN(G/V) denotes a pressure increase pulse duration and K_{PUMP} denotes a pump capability coefficient; a wheel cylinder outflow quantity calculating section that calculates a wheel cylinder outflow quantity Q_{OUT} from a pressure decrease pulse duration DECN(G/V) and a difference in pressure between the master cylinder liquid pressure estimated value $P\hat{\ }_{MC}$ and the first brake liquid pressure $P\hat{\ }_{B}$ at the previous control period multiplied with a cut valve capability coefficient K_{CUT}, when the hydraulic pump pressure increase

occurs; a wheel cylinder variation quantity calculating section that calculates a wheel cylinder variation quantity per unit time dQb/dt from the wheel cylinder inflow quantity Q_{IN} and the wheel cylinder outflow quantity Q_{OUT}; a wheel cylinder liquid quantity calculating section that calculates an integration of the calculated wheel cylinder variation quantity dQb/dt with respect to time to derive a wheel cylinder liquid quantity Qb; and a first brake liquid pressure outputting section that calculates and outputs the first brake liquid pressure $\hat{P}_B$ as follows: $\hat{P}_B = \int(Qb)$.

5. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 3, wherein the first brake liquid pressure estimating section comprises: a pump increase determining section that determines whether a hydraulic pump pressure increase occurs in the model of the pressure controlling section; a wheel cylinder inflow quantity calculating section that calculates a wheel cylinder inflow quantity Q_{IN} when the hydraulic pump pressure increase does not occur as follows: $Q_{IN} = K_{IN} (\hat{P}_{MC} - \hat{P}_B) \bullet INCN(w/c)$, wherein INCN(w/c) denotes a pulse duration time of a corresponding wheel cylinder IN valve, K_{IN} denotes a predetermined IN valve predetermined coefficient, $\hat{P}_{MC}$ denotes the master cylinder liquid pressure estimated value at the previous control period, and $\hat{P}_B$ denotes the first wheel cylinder liquid pressure estimated value estimated at the previous control period; a wheel cylinder outflow quantity calculating section that calculates a wheel cylinder outflow quantity Q_{OUT}

from a pulse duration time of the corresponding wheel cylinder OUT valve DECN(w/c) and the first wheel cylinder brake liquid pressure estimated value $\hat{P}_B$ at the previous control period multiplied with an OUT valve predetermined coefficient K_{OUT}, when the hydraulic pump pressure increase does not occur; a wheel cylinder variation quantity calculating section that calculates a wheel cylinder variation quantity per unit time dQb/dt from the wheel cylinder inflow quantity Q_{IN} and the wheel cylinder outflow quantity Q_{OUT}; a wheel cylinder liquid quantity calculating section that calculates an integration of the calculated wheel cylinder variation quantity dQb/dt with respect to time to derive a wheel cylinder liquid quantity Qb; and a first brake liquid pressure outputting section that calculates and outputs the first brake liquid pressure estimated value $\hat{P}_B$ as follows: $\hat{P}_B = \int(Qb)$.

6. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 4, wherein the master cylinder liquid pressure estimating section comprises: a wheel cylinder brake liquid pressure error calculating section that calculates an error between the first and second wheel cylinder brake pressure estimated values as follows: $P_{B\_ERROR} = \hat{P}_{WC} - \hat{P}_B$; a four-wheel total error calculating section that calculates a total of each error of the four wheels $P_{B\_ERROR\_T}$ as follows: $P_{B\_ERROR\_T} = (P_{B\_ERROR\_FL} + P_{B\_ERROR\_FR}) \times K_{ERROR\_F} + (P_{B\_ERROR\_RL} + P_{B\_ERROR\_RR}) \times K_{ERROR\_R}$, wherein K_{ERROR_F} denotes a front wheel error gain and K_{ERROR_R} denotes a rear wheel error gain and $K_{ERROR\_F} > K_{ERROR\_R}$; an anti-lock brake control execution

determining section that determines whether the anti-lock brake control is being executed and the second wheel cylinder brake liquid pressure estimated value $\hat{P}_{WC}$ is larger than the first wheel cylinder brake liquid pressure estimated value $\hat{P}_B$ and a brake control target value P^*_B; a master cylinder liquid pressure estimated value lower limit value setting section that sets a lower limit value of the master cylinder liquid pressure estimated value $P_{B\_LIM\_MIN}$ to a maximum value of the estimated values for the second brake liquid pressures $MAX(\hat{P}_{WC\_FL}, \hat{P}_{WC\_FR}, \hat{P}_{WC\_RL}, \hat{P}_{WC\_RR})$ to determine whether a sudden brake has occurred when the anti-lock brake control is being executed and the second wheel cylinder liquid pressure estimated value $\hat{P}_{WC}$ is larger than the first wheel cylinder brake liquid pressure estimated value $\hat{P}_B$ and the brake control target value P^*_B; a brake release determining section that determines whether the anti-lock brake control is being executed and $X_G > K_{XG} \bullet (\sum \hat{P}_B) \bullet GAIN_{PB}$ to determine whether the brake manipulation is released, wherein X_G denotes a detected value of the longitudinal acceleration of the vehicle, K_{XG} denotes a coefficient dependent upon a vehicular weight and a brake pad frictional coefficient μ, $GAIN_{PB}$ denotes a predetermined liquid pressure gain, and $\sum \hat{P}_B$ denotes the total of the first wheel cylinder brake liquid pressure estimated value for each road wheel; and a master cylinder liquid pressure estimated value maximum value setting section that sets a maximum value $P_{B\_LIM\_MAX}$ of the master cylinder liquid pressure estimated value from each road wheel second brake liquid pressure estimated value $\hat{P}_{WC\_FL}$. $\hat{P}_{WC\_FR}$, $\hat{P}_{WC\_RL}$, and $\hat{P}_{WC\_RR}$

when the anti-lock brake control is being executed and $X_G > K_{XG} \cdot (\sum \hat{P}_B) \cdot GAIN_{PB}$; and a master cylinder liquid pressure estimated value adjusting section that controls and adjusts the total error $P_{B\_ERROR\_T}$ to make the second wheel cylinder brake liquid pressure estimated value $\hat{P}_{WC}$ equal to the first wheel cylinder brake liquid pressure estimated value $\hat{P}_B$.

7. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 6, wherein $P_{B\_LIM\_MIN} = 0$ when the anti-lock brake control is not being executed or the second wheel cylinder liquid pressure estimated value $\hat{P}_{WC}$ is not larger than the first wheel cylinder brake liquid pressure estimated value $\hat{P}_B$ nor the brake control target value P^*_B.

8. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 6, wherein $P_{B\_LIM\_MAX} = P_{MCMAX}$, wherein P_{MCMAX} denotes a maximum pressure up to which the master cylinder is enabled to be developed when the anti-lock brake control is not being executed or $X_G \leq K_{XG} \cdot (\sum \hat{P}_B) \cdot GAIN_{PB}$.

9. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 6, wherein the master cylinder liquid pressure estimated value adjusting section carries out the following proportional-and-integration control to adjust the master cylinder liquid pressure estimated value:

$\hat{P}_{MC} = \mathrm{limit}(K_{P\_PMC} \cdot P_{B\_ERROR\_T} + K_{I\_PMC} \cdot \int P_{B\_ERROR\_T}dt, P_{B\_LIM\_MAX}, P_{B\_LIM\_MIN})$, wherein K_{P_PMC} denotes a proportional gain of the proportional-and-integration

control and K_{I_PMC} denotes an integration gain of the proportional-and-integration control.

10. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 3, wherein the maximum brake liquid pressure calculating section calculates the maximum brake liquid pressure P_{B_MAX} for four road wheels of the vehicle as follows: $P_{BMAX\_FL} = P_{STAT\_F} - K_X \bullet X_G + K_Y \bullet Y_G$; $P_{BMAX\_FR} = P_{STAT\_F} - K_X \bullet X_G - K_Y \bullet Y_G$; $P_{BMAX\_RL} = P_{STAT\_R} + K_X \bullet X_G + K_Y \bullet Y_G$; and $P_{BMAX\_RR} = P_{STAT\_R} + K_X \bullet X_G - K_Y \bullet Y_G$, wherein X_G denotes a detected value of the longitudinal acceleration of the vehicle, FL denotes a front left road wheel, FR denotes a front right road wheel, RL denotes a rear left road wheel, and RR denotes a rear right road wheel, F denotes a front road wheel side and R denotes a rear road wheel side, K_X denotes a hydraulic pressure conversion coefficient for the longitudinal acceleration, Y_G denotes a detected value of a lateral acceleration, and K_Y denotes a hydraulic pressure conversion coefficient for the lateral acceleration.

11. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 4, wherein $Q_{OUT} = K_{CUT}(\hat{P}_B - \hat{P}_{MC}) \bullet DECN(G/V)$ when the hydraulic pump pressure increase occurs and $Q_{OUT} = K_{OUT} \bullet \hat{P}_B \bullet DECN(w/c)$ when a master cylinder pressure increase occurs but the hydraulic pump pressure increase does not occur.

12. A brake pressure estimating apparatus for an

automotive vehicle as claimed in claim 11, wherein $Q_{IN} = K_{IN} \bullet (\hat{P}_{MC} - \hat{P}_{B}) \bullet INCN(w/c)$ when the master cylinder pressure increase occurs but the hydraulic pump pressure increase does not occur.

13. A brake pressure estimating apparatus for an automotive vehicle as claimed in claim 4, wherein $dQb/dt = Q_{IN} - Q_{OUT}$.

14. A brake pressure estimating method for an automotive vehicle, the automotive vehicle comprising: a brake system including a master cylinder which develops a hydraulic in response to at least a brake manipulation as a hydraulic source and a brake pressure controlling section that is enabled to arbitrarily control a brake pressure of each wheel cylinder, the brake pressure estimating method comprising:

estimating a first brake liquid pressure of the wheel cylinder of each road wheel on the basis of a model of the brake pressure controlling section for each control period;

estimating a second brake liquid pressure of the wheel cylinder for each road wheel on the basis of a vehicular model with a vehicular state as an element of the model for each control period; and

estimating a liquid pressure of the master cylinder for each control period on the basis of the first and second brake liquid pressure estimated values of the wheel cylinder of each road wheel, at the first wheel cylinder liquid pressure estimating, calculating the first brake liquid pressure of the wheel cylinder of each road wheel on the basis of the

master cylinder liquid pressure estimated value estimated at a previous control period and the first liquid pressure estimated value estimated at the previous control period, at the second wheel cylinder brake liquid pressure estimating, detecting a vehicular state and calculating the second wheel cylinder brake liquid pressure for each road wheel from the detected vehicular motion state, and, at the master cylinder liquid pressure estimating, outputting the master cylinder liquid pressure estimated value to make a difference between the first wheel cylinder brake liquid pressure estimated value and the second wheel cylinder brake liquid pressure estimated value small to cause the master cylinder liquid pressure estimated value to be converged into a true value thereof.